EFFICIENT AND EFFECTIVE DATA ACQUISITION

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INTRODUCTION

New technologies are emerging nearly every day which enable government agencies and private companies to manage and manipulate huge amounts of data. There is also an ever growing need to optimize investments in infrastructure by making more efficient use of those facilities that are already built. These two trends are converging in the field of Asset Management.

Emphasis is often placed on the uses of data such as Geographic Information Systems (GIS) applications and database mining. What is sometimes overlooked is the actual acquisition of field data and the balance of efficiency and effectiveness. This paper will address field operations and equipment as well as explain initial steps needed and potential pitfalls.

The field of Asset Management is continuing to grow and evolve. Inventories of the constructed environment of roads, sidewalks, utilities, etc., sometimes referred to as "grey infrastructure", are desired, but so too are inventories of the "green infrastructure" such as trees and vegetation. The data collection processes described in this paper can be applied in any of these situations.

INITIAL PLANNING

As with any significant effort, proper planning from the onset is crucial. A thorough understanding of the magnitude, constraints, time frame, safety issues, and data to be collected is required.

The overall cost of a project is more or less proportional to its magnitude. Clearly the cost per item being inventoried will fall through economies of scale as the number increases. Thus, it may be more prudent to broaden the scope of work for an inventory as opposed to phasing components of it over several years.

Constraints can take many forms. From a managerial viewpoint, issues related to intergovernmental coordination may be constraining and must be resolved. Often, the need to conduct an asset inventory is the result of regulatory requirements. Many times, the inventory will necessitate the coordination and perhaps concurrence of several governmental units. Financial constraints, of course, also need to be considered. From a field work standpoint, practical considerations such as weather, tree canopy, and the presence of buildings (if using Global Positioning System (GPS) technologies) must be addressed.

The project schedule must account for not only the overall time frame of the project, but seasonal considerations as well. Working through winter months in some parts of the country may be difficult if not impossible. Even if weather conditions allow for field work without jeopardizing the safety of field personnel, the lack of sunlight could hinder data collection operations and reduce the time available during the day.

Safety issues must also be considered. Many municipal utilities are located in public rights-of-way. Once field personnel begin working in these areas, even for a short time, proper traffic control measures will be required to assure not only worker safety but the safety of the public. Most state or local transportation departments have guidelines for the Management of Traffic (MOT) that must be followed. MOT plans typically fall into one of two broad categories: long term stationary controls and moving controls. Asset management data collection may fall in between the two. Establishment of proper traffic control measures and subsequent inspections can sometimes take ten or fifteen minutes. This situation may not be long enough to be considered permanent but cannot be considered moving either. A specialized traffic control plan may be warranted and the responsible transportation agency should be consulted.

Traffic control is an integral part of worker safety.

If the inspection program involves storm or sanitary sewers or entry into any other type of confined space, confined spaced entry procedures are likely to be required. Inspection crews will require specialized training to conduct confined space entries, and must be provided with the necessary equipment for such entries. Portable gas meters, tripods, safety winches and a cell phone must all be made available if a confined space entry is to occur.

Prior to the development of a data collection program, the format of the final database structure must be defined. The final database, associated data dictionary, and any business rules will determine what data must be collected, how the data will be collected, and how the data will be managed. The design of a stand alone database will be different from that of a database that must interface with existing systems such as a work order management system. The needs of the end user must be carefully considered to ensure that the collected data is delivered in a way that is useful to as many people as possible. In long duration programs, this can be especially challenging. The change of a key stakeholder could have a significant impact on the perceived needs of the project. However, changes may not be prudent from either an implementation or financial perspective.

For large or long duration projects, it may be beneficial to develop a program manual. The manual will provide a benchmark for all field crews to work from as well as assist new members to the project team in becoming proficient. A project manual could include sections on topics such as:

- Project Contacts
- Field Procedures
- GPS Survey and Structure Numbering
- Condition Inspections & Dry Weather Flow Screening
- Closed Circuit Television (CCTV) Inspection
- Field Equipment
- Emergency Action Plan
- Confined Space Entry
- Traffic Control
- Field Forms

FIELD ACTIVITIES AND DATA COLLECTION

Once project planning is completed, the project can move forward. In a general sense, this involves a four-step process: research, surveying, inspections, and data delivery. Each of these steps is linked to and supports data management.

Research

Prior to conducting field work, it is useful to first obtain any existing information. Not only will existing plans aid in the location of assets, the plans will help to identify ownership, should that be an issue. Construction drawings, record plats, as-built plans, and previous surveys can all aid survey teams in asset location and assure a complete and accurate inventory is conducted.

GPS Survey Work

Fieldwork involves two primary activities. First, is the determination of asset location, often using GPS equipment. Second, are the field inspections that can include data collection, photography, and the generation of maintenance work orders. Depending on the type and scope of project, these activities can be completed together or separately. For purposes of this discussion, it is assumed that survey work is performed separate from the inspection work.

Survey crews can not only locate assets, they can act in a reconnaissance role and identify issues that may cause difficulty for the inspection crews. Commonly the reconnaissance takes the form of noting where traffic control will be required to complete inspection work. However, access issues can be identified as well.

The accuracy level needed during the survey is dependent on the final use of the data collected. If the data is to be used as a part of a GIS, it is likely that surveyed positions need only be accurate to within a meter. Most networked systems (storm sewers, water mains, electrical transmission lines) have nodes every few hundred feet. If that is the case, the cost of conducting a survey with sub-meter accuracy may

be prohibitive. A single surveyor using a backpack or handheld GPS data collector is able to survey 50 to 100 positions a day, depending on density of the features.

If GPS equipment is used, the operator must be familiar with capabilities and limitations of the GPS system. Due to satellite motion, there are times during the day when it is not possible to receive a signal with enough quality to provide a position with the required accuracy. Tree cover and buildings can also prove problematic as they can block the line of sight to one or more GPS satellites and make it difficult to obtain an accurate position. Many GPS systems have the capability to generate an offset position. Often it is possible to collect a position where the GPS signal is strong and, using a bearing and a range, translate that position to an asset that is in an area with a weak GPS signal. The GPS survey data is easily integrated into a GIS, merged with parcel maps, orthographic photos, or other GIS themes and base maps and can be generated for use during the inspection phase of the project.

Finally, it is helpful to mark each asset in some consistent manner for future reference. By assigning a unique identifier to each asset, survey data, inspection data, photographs and any other collected information can be more easily compiled into a format usable by the end user.

Inspection Work

Inspection crews utilize the survey locations and accessibility information to complete asset data collection. The specific data that will be collected during the inspection phase will have been determined during project planning and will typically include the type of structure (asset), physical dimensions, materials of construction, and a general assessment of condition or structural integrity. If inspecting drainage or sewer systems, pipe size and material data could be collected as well. During the inspection phase, dry weather screening of drainage systems or inflow and infiltration analysis of sanitary piping can be performed. Connectivity with other structures should also be determined at this stage to allow for a network to be constructed within the GIS.

Connectivity is crucial in instances where flow is detected in a drainage system during dry weather. This flow would be indicative of an illicit discharge into the system and the connectivity will aid in tracking down the offending party.

An inspection and condition assessment can be performed in as little as 10 or 15 minutes.

There are two primary methods for field data collection. The more traditional method would be to use paper inspection forms. Paper forms are easy to use in the field, are universally understood, and present an inexpensive method to collect data in the field. Paper forms would be appropriate for small projects where a limited amount of field data will be collected. When field work approaches the level of a few hundred inspections, the use of paper forms becomes cumbersome. Each paper form will need to be manually entered into the database, creating a high probability of keystroke errors. Additionally, paper inspection forms do not provide a built in quality verification process.

The use of a Personal Digital Assistant (PDA), tablet PC, or other portable electronic device brings efficiency, quality and ease of use together. An inspection program can be tailored to the needs of the specific project that presents field crews with a standard set of inspection forms. Each form could

contain specific "questions" and a set list of responses to choose from. In specific cases (such as the street address for an asset) a free text field could be used. The uses of standard forms and pick lists helps to minimize subjectivity and increase standardization between inspection crews. The inspection program brings elements of quality assurance to the inspection process as well.

The inspection program can be developed to require certain data be recorded before moving on to the next data screen. The program can also prohibit text characters from being placed in a numerical field. It is, therefore, less likely that a pipe size of "t" inches would be recorded in the database. Finally, the inspection program can check previous records to ensure that a specific asset ID has not been previously used, helping to minimize instances of duplicity within the final database.

When the field device is returned to the office, it is easily connected to a computer and the field data is transferred into the parent database quickly and with minimum chance of error. The use of an electronic field device for data collection will require a certain level of training to assure proficiency by field crews, however the benefits to data collection far outweigh any learning curve that must be overcome.

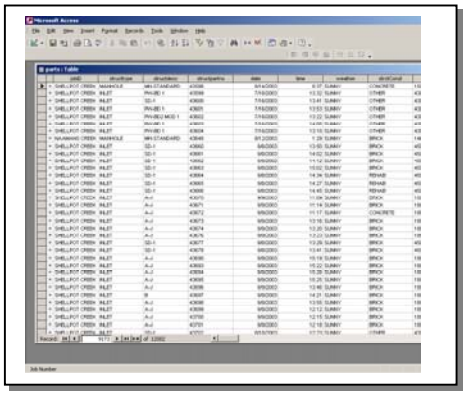
Advances in digital photography have made the development of a visual record of each asset extremely easy. Available digital cameras are high resolution, have the ability to store 100 or more photos (depending on the chosen resolution) and can function for a full inspection day on a single set of batteries. A photo of an asset helps the structure be located in the future and provides a complete record of its condition. If digital photos are to be taken, it is recommended that a log of photos taken be maintained. This log will aid in renaming the photos at a later date by reflecting what each picture represents.

DATA MANAGEMENT

In a large asset inventory project with several independent crews collecting data, standardization is critical in the assessment of an asset as well as the methods used to collect, record and process data. Each person working on the project must understand that the data they are collecting will likely be reviewed and processed by another individual. A GIS Analyst might manage the download and processing of survey field inspection data. Another project member may deliver maintenance work orders to the client, while a third person organizes field photographs. It may seem burdensome to have several people involved in the data management process, but the types of tasks and the volume of data may necessitate it. The benefit to this approach is that additional reviews offer more opportunity for quality assurance checks as well as allowing all project members exposure to the project as a whole and not just a single isolated aspect.

The initial survey work may not identify 100% of the existing infrastructure under consideration. Additional features may be identified during the inspection process that will need to be surveyed. This can be the result of recent construction, buried utilities in easements that were previously not identified, or access issues. In any event, during the office review these features can be identified and surveys completed as a part of the QA/QC process.

Similarly, assets may exist that could not be inspected. Parked vehicles, residential fences, dense brush, structures that cannot be opened, or other impediments may prevent inspection from occurring. In some cases, the inspection can occur if the asset is visited at a later date. During fall and winter months, dense brush is not a problem. If a vehicle is blocking an asset one day, it will likely be gone the next. In any event, these assets must be tracked until they are inspected or the decision is made to leave them un-inspected with the issuance of a maintenance work order to address access issues.



Data can be delivered in multiple formats.

Prior to delivering the final database and associated GIS, the data should be reviewed for completeness and connectivity if a network has been developed. Once the data has been verified, any images are processed and the map network is complete, a Utility Data Management System (UDMS) can be delivered to the client and made available for general use.

POTENTIAL PITFALLS

The complexities of conducting a thorough asset management data collection campaign are numerous and cannot be overstated. From a data management standpoint, perhaps the most important issue is assuring that the end product meets the needs of the client not only in breadth but format as well. This reemphasizes the need to document decisions made at the onset of the project and obtain buy in from all potentially affected parties as to database structure and associated business rules. Something as simple as the method to store an address field can have significant impact on the usefulness of the final UDMS. Should the address be a single field? Or, is it better to have three fields (one field for the street name, another field for a house number, and a third field for street type such as Road or Lane)? This single decision may impact if and how the UDMS data can be linked to an existing database. Periodic meetings are critical as new people are brought into the project and hardware and software advances provide new options for both field and office application.

Training is the single most critical aspect to success of any data collection project. Field crews must be trained to work in and around traffic. Training must also be conducted on general aspects of field safety including fall hazards, drop hazards, heat and cold stress (as applicable) and general environmental issues (animals, bugs, and plants). If the work will involve entry into closed systems (manholes, tanks, vaults, drainage inlets, etc.), confined space training must be provided.

From a data collection perspective, procedures and terminology must be well defined. This will ensure that from crew to crew, the same standards are applied during the inspection process resulting in consistent evaluations. A well defined QA/QC process will identify and correct many problems. However, the best solution is to not create the error in the first place.

BENEFITS AND APPLICATIONS

The collection of large amounts of data in an efficient manner has many benefits. Phase II of the National Pollutant Discharge Elimination System requires the location and identification of outfalls in order to track down sources of illicit discharges. Changes to accounting practices (GASB34) allows for the depreciation of municipal assets. This can only be accomplished if the condition of existing assets is known. Finally, an inventory of municipal assets will aid in prioritizing investments in the infrastructure and help plan for future capital expenditures.